DRAFT INTERAGENCY MEMORANDUM

To: **Cooperating Agencies in the NorthMet Project EIS**

From: **NorthMet EIS Project Managers**
Michael Jimenez (USFS); Doug Bruner (USACE); Lisa Fay/Bill Johnson (MDNR)

Re: **NorthMet Environmental Impact Statement**
Co-lead Agencies' Consideration of Possible Mine Site Bedrock Northward Flowpath

June 22, 2015

Executive Summary

PolyMet developed a groundwater flow model of the NorthMet Mine Site and surrounding area using the U.S. Geological Survey MODFLOW model to estimate groundwater inflows to the proposed NorthMet pits. The model assumed artificially high Northshore pit lake elevations that would lead to conservatively high groundwater inflows to the proposed NorthMet pits during Northshore operations and before the proposed NorthMet pits refill. Recent comments from the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) suggested that a north bedrock groundwater flowpath from proposed NorthMet pits to Northshore pits could occur after closure at Northshore.

The Co-lead Agencies reviewed available information in the context of GLIFWC's comments and concluded that the lack of hydrologic response at the proposed NorthMet Project Mine Site supports a conceptual model whereby water from the proposed NorthMet pits would not flow into the Northshore pits. Site-specific groundwater monitoring data and the measured lack of surface water effects near the dewatered Northshore pits are consistent with the conceptual model that downward leakage from surficial deposits into bedrock could create a groundwater mound. This would prevent the formation of a northward bedrock flowpath from the proposed NorthMet pits to the Northshore pits.

However, the Co- Lead Agencies acknowledge that the data and the NorthMet MODFLOW model do not definitively rule out the possibility of a northward bedrock flowpath from the proposed NorthMet pits to the Northshore pits. Therefore, to address the theoretical possibility of a northward flow, a bedrock water-level monitoring program would be implemented in the area north of the proposed NorthMet pits to measure bedrock water levels during and after operations. Monitoring would provide advance notice of any potential development of a northward bedrock flowpath from the proposed NorthMet pits to the Northshore pits. If monitoring data indicate that development of a northward flowpath from the proposed NorthMet pits to the Northshore pits is probable, then adaptive mitigation measures would be implemented to address (i.e., prevent) the potential flowpath. Existing monitoring data, in combination with a robust monitoring and adaptive management plan, will ensure with reasonable certainty that any potential northward bedrock groundwater flow from the proposed NothMet pits to the Northshore pits would be addressed and prevented.

Minnesota DEPARTMENT OF NATURAL RESOURCES

US Army Corps of Engineers
St. Paul District

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

1.0 Background

PolyMet developed a groundwater flow model of the NorthMet Mine Site and surrounding area using the U.S. Geological Survey MODFLOW model, the details of which are described in Barr 2015. The primary purpose of the Mine Site MODFLOW model was to estimate groundwater inflows to the proposed NorthMet pits (Barr 2008). The model also used fixed head cells (i.e., a static pit water elevation) to simulate the Northshore pit lakes, with water-level elevations set at 1,617 ft above mean sea level (amsl). Since the primary purpose of the model was to estimate groundwater inflows to the proposed NorthMet pits, the model used assumptions for the area north of the proposed NorthMet pits. It was acknowledged that the Northshore pit lake water levels might be artificially high using this method, but the Co-lead Agencies supported this approach since it would lead to conservatively high groundwater inflows to the proposed NorthMet pits during Northshore operations and before the proposed NorthMet pits refill. The Co-lead Agencies agreed to this approach in their review and subsequent approval of document RS22 (Barr 2008).

The Co-lead Agencies received comments on the Mine Site FEIS MODFLOW (MODFLOW) model from the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) during FEIS preparation. GLIFWC modified the existing MODFLOW model to evaluate the potential for flow to the north towards Northshore instead of its intended purpose of estimating NorthMet Mine pit inflows. In addition, the model was changed to reflect anticipated future water levels in the Northshore pits, which are expected to be lower than the estimated water levels in the proposed NorthMet pits. For this condition, it was predicted that northward flow through bedrock may be possible. However, this model outcome assumes negligible downward leakage from surficial deposits into the bedrock in the area of the 100 Mile Swamp. In reality, the assumption of negligible downward leakage is unsubstantiated from available data. This is critical since the amount of downward leakage influences the presence or absence of a groundwater divide between the proposed NorthMet pits and the Northshore pits (see Section 1.1, Site Hydrogeology). The purpose of the NorthMet EIS MODFLOW model was to evaluate water flowing into the proposed NorthMet pits; had its purpose been to evaluate the potential for flow to the north, the model would have been constructed differently, and likely would have resulted in different predictions than were reached by the analysis performed by GLIFWC.

1.1 Site Hydrogeology

Figure 1 shows the area between and including the proposed NorthMet Mine and the Northshore Mine. It includes natural and man-made features, and the surface geologic contacts between the major bedrock units. At the NorthMet Mine, two open pits are proposed: the West Pit and the East Pit, with the latter being a consolidation of two pits excavated during the first part of operations. The current bedrock groundwater levels at the proposed NorthMet Mine Site are about 1,600 to 1,610 ft amsl.

At the Northshore Mine, there is a large excavation that is divided into several areas that contain individual mine pits separated by bedrock walls. Currently, Area 003 West has pit lakes with water levels at about 1,624 ft amsl, Area 003 East is dewatered with a pit bottom elevation of about 1,568 ft amsl, and Area 002 has dewatered pits with elevations as low as 1,380 ft amsl. From southeast to northwest, the bedrock units at ground surface consist of Duluth Complex, Virginia Formation, and Biwabik Iron Formation (BIF). Duluth Complex rocks are interpreted to have a very low bulk hydraulic conductivity of about 5 x 10^{-4} ft/day, while the Virginia and Biwabik Formations are considered to have bulk hydraulic conductivities about three orders of magnitude higher (3×10^{-1} to 9×10^{-1} ft/day) respectively. The bedrock contacts generally dip south-southeast and the downward stratigraphic progression from younger to older is Duluth Complex, Virginia Formation, and BIF.

Figure 2 shows a north-south vertical cross-section passing through the proposed NorthMet West Pit and along section trace A-A' on Figure 1. As can be seen in the section, the bedrock contacts dip southeast at about 25 degrees in the area between the proposed NorthMet Mine Site and Northshore Mine, and the dip angle increases to about 45 degrees in the vicinity of the proposed NorthMet West Pit. The Area 003 West pits are excavated into the BIF except for an exposure of Virginia Formation at the top of the south pit wall. An important distinction is that the proposed future NorthMet West Pit would be excavated only into the low-permeability Duluth Complex and this explains why relatively low pit dewatering rates (about 80 gpm) are estimated in the EIS for the proposed NorthMet West Pit during operations.

Figure 3 shows a north-south vertical cross-section passing through the proposed NorthMet East Pit and along section trace B-B' on Figure 1. The orientations of the bedrock contacts are similar to Section A-A' on Figure 2. Of importance is that the north wall of the proposed NorthMet East Pit is excavated into the higher permeability Virginia Formation and this explains the relatively high pit inflow rate (760 gpm) estimated in the EIS for the proposed NorthMet East Pit during operations. The bedrock between the proposed NorthMet East Pit and the Area 003 East pits consists of higher permeability Virginia Formation and BIF. For this reason, the focus of this Co-Lead Agencies' review is on the theoretical possibility of a northward flowpath between the proposed NorthMet East Pit and the Area 003 East pits.

Table 1 shows estimated water levels at NorthMet and Northshore for different time points. As can be seen for current and future conditions, water-level elevations at the Northshore Area 003 East pit are, and would continue to be, lower than water levels at the proposed NorthMet East pit. Absent other sources of water entering bedrock between the two areas (such as the 100 Mile Swamp), this could establish a bedrock hydraulic gradient that could drive northward flow in bedrock between the two sites.

Table 1: Groundwater Level Elevations at the NorthMet and Northshore Sites

Condition	Year		NorthMet Mine Site		Northshore Site		
	Calendar	Mine	West Pit	East Pit	Area 003 West	Area 003 East	Area 002
Current	2015	0	1,600 to 1,610 (a)	1,600 to 1,610 (a)	1,624 (b)	1,568(c)	1,380 (c)
End of Northshore Operations	2070	55	1,576 (b)	1,592 (b)	1,350 (c)	1,300 (c)	1,250 (c)
Long-Term Closure	2080+	65+	1,576 (b)	1,592 (b)	1,500 (b)	1,500 (b)	1,500 (b)

Notes:

(a) Water levels in bedrock monitoring wells (ft amsl)

(b) Pit lake water level (ft amsl)

(c) Bottom of dewatered pit (ft amsl)

Northshore water level lower than NorthMet Mine Site water level

The Northshore Area 003 West Pit Lake is presently only tens of feet deep. The Northshore 003 West Pit and 003 East Pits will be mined over the next several decades until closure. It is anticipated that the Northshore pits will continue to be dewatered after the proposed NorthMet pits have refilled. However, the timing and duration of Northshore pit dewatering it is not precisely known.

1.2 NorthMet Mine Site Bedrock Conceptual Groundwater Model

Groundwater model development includes designing a conceptual model, or a visual representation of the flow system. This can be cross-sections or even a diagram. The conceptual model is a simplification of the system that is true to the available field data. For the NorthMet Mine Site MODFLOW modeling, a key factor in the conceptual model is the amount of downward leakage from the surficial deposits into bedrock. Figures 4 and 5 show the hydrologic conceptual model developed to qualitatively evaluate bedrock groundwater flow between the proposed NorthMet pits and the Northshore pits (at closure). From ground surface downward, the key components of the conceptual model are:

- Northshore pits and proposed NorthMet pits excavated into bedrock would both contain pit lakes during long-term closure.
- 100 Mile Swamp, which is primarily fed by surface water runoff and hydrologically constitutes the equivalent of an extensive shallow lake, can provide recharge to groundwater.
- Surficial deposits have relatively high horizontal hydraulic conductivity and are hydraulically connected to surface water in the 100 Mile Swamp.
- BIF and Virginia Formation have moderate hydraulic conductivity and can receive downward leakage from the overlying surficial deposits.

Figure 4 shows the expected flow hydraulics after closure for the case where downward leakage from the surficial aquifer and 100 Mile Swamp is sufficient to cause a bedrock groundwater mound to develop between the NorthMet Mine Site and the Northshore Mine. A bedrock groundwater mound is defined here as a zone of saturation within bedrock in the shape of a mound that may develop between the NorthMet and Northshore mines. This mound would constitute a bedrock groundwater divide between the mines thereby preventing flow from the NorthMet Mine to the Northshore Mine. High-level, conceptual scoping calculations (i.e., not a detailed simulation of the real system) performed by ERM suggest that for long-term closure conditions at Northshore, a bedrock groundwater mound would develop for an aerially averaged downward leakage flux of about 2.3 in/yr or greater. At the end of Northshore operations, similar scoping calculations suggest a bedrock groundwater mound would develop with 8 in/yr of an aerially averaged downward leakage flux; see Table 1. The source of this water is likely from the 100 Mile Swamp.

Figure 5 shows the expected flow hydraulics for the case where downward leakage is negligible. For this situation, the mound does not develop, there is no drainage divide, and the bedrock system would have continuous northward flow from the proposed NorthMet East Pit to the Northshore pits. Scoping calculations suggest that this situation could develop if the aerially averaged downward leakage flux from surficial deposits into bedrock is *less than about 2.3 in/yr in Northshore closure, and less than about 8 in/yr at the end of Northshore operations; see Table 1.*

2.0 Evidence of No Northward Bedrock Flowpath

More specifically, there are two lines of evidence to suggest that a northward bedrock groundwater flowpath is *not* likely to develop between the proposed NorthMet Mine Site and the Northshore Mine:

- No apparent response in existing NorthMet bedrock monitoring wells (i.e., water levels) to decreasing Northshore Area 003 East pit water levels; and
- No apparent effects on lakes and wetlands adjacent to the existing dewatered Northshore pits.

Figure 6 shows groundwater levels in five NorthMet Mine Site bedrock wells (two of which are in the Virginia Formation, the other three in the Duluth Complex) during an eight-year period from 2007 to 2015. Prior to and during this period, pit deepening and dewatering was occurring in Northshore's Area 003 East, and by 2010 the water level at Area 003 East was more than 40 feet below the NorthMet bedrock water levels. As shown on Figure 6, the bedrock water levels in the NorthMet monitoring wells were stable during the period of record and did not exhibit any apparent responses to the decreased hydraulic heads at the Area 003 East pits.

While this evidence is meaningful in attempting to understand existing bedrock groundwater behavior and may indicate vertical leakage between surficial deposits and bedrock, it is not definitive in that Area 003 West Pit water levels were stable and relatively high during the period of interest. The presence of high water levels at the Area 003 West Pit could have reduced the extent of bedrock drawdown associated with low water levels at Area 003 East. However, if the conceptual model with negligible leakage (Figure 5) was operative, one would have expected to see at least some drawdown in the NorthMet bedrock monitoring wells.

Another line of evidence comes from the presence of lakes in close proximity to the Northshore Mine pits. As shown on Figure 7, Iron Lake and Argo Lake are close to the Northshore pits despite the fact that the pits have been excavated and dewatered for many years. The current dewatered pit depths at Area 002 (1,400 to 1,650 ft amsl) are substantially lower than the current water levels in Iron Lake (1,760 ft amsl) and Argo Lake (1,745 ft amsl). Figure 8 shows that since the early 1960s, the water levels in these lakes do not appear to have been drawn down by the dewatering activities associated with the nearby Northshore pits. Hydraulic calculations suggest that bedrock drawdowns should occur near dewatered mine pits, but in spite of this, there is no apparent effect on the two lakes.

The behavior of Argo Lake and Iron Lake is similar to other observations across the Iron Range where surface water features (including wetlands) exhibit no apparent response to the dewatering of nearby mine pits (MDNR 2008). Several factors could be limiting the lake responses such as: (1) poor hydraulic communication between the lake bottoms and bedrock; (2) sufficiently high inflow to the lakes from rainfall, runoff, or surficial deposit seepage to mask the downward leakage that might be occurring into bedrock; and/or (3) induced downward leakage from surficial deposits into bedrock that reduces the extent of the bedrock drawdown response. If the third factor were dominant, it would provide evidence that the conceptual model on Figure 4 (i.e., groundwater mound) could ultimately operate between the proposed NorthMet pits and the Northshore pits. However, because any or all of the three factors could be significant, the lack of water-level response in Iron Lake and Argo Lake does not definitely eliminate the possibility of a future northward flowpath between the proposed NorthMet pits and the Northshore pits.

3.0 Monitoring and Mitigation Strategies

Monitoring would be applied to detect whether a northward flowpath between the proposed NorthMet pits and Northshore pits might occur. If indeed detected, engineered mitigation measures would be available to address and prevent such a flowpath from occurring as necessary.

3.1 Monitoring

The goal of monitoring would be to determine the flow direction of bedrock groundwater between the NorthMet and Northshore sites for purposes of identifying any need for engineered mitigation measures. Monitoring wells would measure bedrock groundwater levels starting in mine year 1 and determine if groundwater flow is southward towards the proposed NorthMet pits or northward away from the pits. PolyMet proposes an enhanced monitoring system that includes eight bedrock wells (or piezometers) north of the proposed NorthMet pits, and four to the south of the pits, to achieve this goal (Figure 9); see Barr 2015a. In addition to these wells, the Co-lead Agencies recommend an additional groundwater well north of the East Pit. West Pit and East Pit water level elevations would also be monitored. At the direction of regulatory agencies, additional wells could be added to the monitoring network.

The number and location of proposed and recommended monitoring wells is based upon a three-point monitoring network design. The monitoring points in the network are: water levels in pits; near field water levels; and far field water levels. Two rows of monitoring wells would be placed along the entire north edge of the NorthMet Mine Site where a potential flowpath could develop. The monitoring wells would also be grouped more tightly north of the East Pit, which would be expected to have a higher likelihood than the West Pit to develop a northward flowpath. Monitoring of proposed NorthMet pit water level elevations would complete the network. Taken together, the network would provide sufficient data to determine groundwater flow direction. Additionally, monitored Northshore pit water elevations would also be available to inform decisions.

If flow is northward from the NorthMet Mine Site, additional site characterization would be performed to inform the type and design of adaptive mitigation to be implemented. After mitigation is implemented, the monitoring wells would continue to be used to verify system performance.

In terms of timing, water-level monitoring would start in mine year 1 and continue for the life of the NorthMet Mine. Conditions potentially supporting development of a northward flowpath would not exist until water levels in the NorthMet East Pit are higher than at the Northshore pits. Therefore, engineered mitigation measures, if necessary, would not be needed until at least 15 years after mining begins. This would provide ample opportunity to collect necessary data, and complete applicable environmental review and/or permitting, engineering and construction prior to the development of a northward flowpath (if one were to form at all). The data collected during mining operations would provide regulators with information to evaluate potential adaptive mitigation approaches and their scale. *If delays are experienced during the engineering design process, depressed pit water levels (via dewatering) could be maintained until engineered mitigation is in place to assure no development of a northward flowpath.*

New bedrock monitoring wells within the 100 Mile Swamp would be installed during the winter and require temporary road access for equipment. After well installation, water-level measurements would be taken continuously, with hand measurements likely taken at least several times per year to corroborate (or correct) automated data collection. The environmental impacts associated with monitoring well installation and monitoring activities are expected to be minimal.

3.2 Adaptive Management and Mitigation

Adaptive management is a system of management practices, based on clearly defined outcomes and monitoring requirements, that assesses whether management actions are meeting the desired outcomes, and, if not, they are facilitating changes that would ensure the defined outcomes are met. In considering the potential for a northward flowpath, adaptive management measures are engineered solutions for which the design evolves over time in response to new information. The purpose of adaptive mitigation in this instance is to address, and if necessary prevent, a continuous northward flow of pit water from the proposed NorthMet pits to the Northshore pits. By the time adaptive mitigation may be needed, much more would be known about the NorthMet site's hydrogeology given the data obtained during the early operational period, including actual pit inflows and hydraulic conductivities of bedrock and surficial deposits. It is expected that at least 15 years of monitoring data would be available to inform adaptive mitigation options before engineered solutions could be needed and constructed. Options and associated designs would continue to be refined throughout this data collection period so that an effective engineering design is available (if needed) to prevent any adverse impact.

There are a number of adaptive mitigation measures that could be implemented, either individually or in combination with one another, which would prevent any potential adverse impact. The exact type, location, and timing of adaptive mitigation measures are not known at this time. These measures are discussed conceptually because more site data would be necessary to complete detailed designs. Other methods to prevent northward bedrock groundwater flow from the proposed NorthMet pits to the Northshore pits may also become feasible as the hydrogeology is better understood during mine operations.

The description of each measure also includes a brief qualitative assessment of potential environmental effects. This is based upon the theoretical application of these mitigation measures and the water management dynamics understood through the evaluation of the NorthMet Project Proposed Action. If adaptive mitigation is necessary, the action would need to meet all applicable environmental review and permitting requirements.

> ***Pit Lake Depression*** - PolyMet could lower water levels in the NorthMet West Pit or East Pit (or both) by pumping to ensure that hydraulic gradients cause groundwater to flow towards the proposed NorthMet pits and prevent any northward flow from the proposed NorthMet pits to the Northshore pits. The conceptual hydraulics for this measure is shown on Figure 10. The exact pit water levels required would depend on the extent of downward leakage from surficial deposits in the area of the 100 Mile Swamp (to maintain a mound and bedrock groundwater flow toward the proposed NorthMet pits), Northshore pit water elevations, and the potential implementation of other complementary mitigation measures.
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> The benefit of lowering the West Pit and East Pit water elevations would be the elimination of all surficial deposit and bedrock flowpaths (north and south) from the NorthMet Mine Site. However, this measure would expose pit walls to oxygen (and affect the volume of waste rock that the East Pit could accept), which could increase the chemical loading to the West Pit lake water and East Pit pore water. Reduced pit water quality and increased pit pumping would require a higher capacity water treatment facility and possibly additional treatment processes entailing additional expense. If pit wall grouting were to be done, and if it proved effective, it would lower pit inflow and Waste Water Treatment Facility (WWTF) discharge rates. Treated

water would likely be discharged to the Partridge River in closure and increase its flows in comparison to the NorthMet Project Proposed Action. In addition, transition to a non-mechanical treatment system may likely be more difficult. With a depressed water level, construction of a wetland in the East Pit would likely be limited, and the Category 1 waste rock stockpile may need to be expanded, or other waste rock management actions be considered. Short-term application of the strategy would likely have lesser consequences to pit water quality or operational requirements than long-term. Additionally, using artificial recharge in combination with pit lake depression could reduce these effects.

Groundwater Extraction Wells - Using extraction wells, PolyMet could pump water from bedrock to create a hydraulic depression in the bedrock groundwater system between the NorthMet and Northshore sites. The conceptual hydraulics of this engineering option is shown on Figure 11. The extent and configuration of the wells would depend upon the width of the northward bedrock flowpath and the hydrologic properties of bedrock. Additionally, the extraction well option could be considered along with artificial recharge (described below).

This system would increase flow rates to the WWTF. Potential flow rate increases to the WWTF could be reduced by using some of the extracted water to saturate the East Pit backfill. If pit wall grouting were to be done, and if it proved effective, it would lower extraction well pumping rates. Bedrock extraction wells would induce a north flow from the NorthMet Mine Site to the extraction wells, but no further. After the pits fill, water chemistry would stabilize and gradually improve as predicted under the NorthMet Project Proposed Action. Due to slower refill, the start of bedrock and surficial groundwater flow toward the Partridge River would be delayed when compared to the NorthMet Project Proposed Action.

Long-term WWTF influent water quality would not likely differ significantly from that modeled for the NorthMet Project Proposed Action. However, WWTF influent flow rates would likely be greater as it would consist of both pit pumping and bedrock well pumping. This would increase the NorthMet Project Proposed Action discharges to the Partridge River.

Wetlands would be directly impacted from groundwater extraction well installation and access road construction. The number of acres of ground disturbance is unknown as the location and number of wells is unknown.

Artificial Recharge – A bedrock groundwater mound can be artificially created between the NorthMet Mine and the Northshore Mine by increasing recharge into bedrock via wells, an infiltration trench, or both. The recharge water would need to be free of particulates to minimize clogging. Periodic well or trench redevelopment would be required. The extent and configuration of the artificial recharge system would depend upon the width of the northward bedrock flowpath. Both treated WWTF effluent or un-impacted (i.e. non-contact) stormwater would be available indefinitely during closure, and could provide water for recharge. Figure 12 shows conceptually how an artificial groundwater mound would create a flow divide between the NorthMet Mine Site and the Northshore Mine, and prevent the flow of pit water from the proposed NorthMet pits to the Northshore pits. If this option is considered, bedrock well field tests would be necessary for further evaluation of this option. This option could be considered along with extraction wells to prevent the recharge water from migrating to the Northshore pits.

Artificial recharge would induce southern bedrock groundwater flow towards the West Pit and/or East Pit. Because the recharge water would have low chemical concentrations, it is unlikely to adversely affect pit water quality. As a result, estimates of bedrock and surficial deposit groundwater water chemistry entering the Partridge River from the Mine Site are unlikely to be significantly different from what is currently modeled in the FEIS. Surficial deposit groundwater flowpaths and flow rates to the Partridge River are unlikely to change significantly from what is currently predicted in the FEIS. Furthermore, the flow rates and effluent quality of the WWTF that would be discharged to a tributary of the Partridge River are unlikely to be significantly different from what is currently modeled in the FEIS.

Wetlands would be directly affected from recharge wells and/or infiltration trench and access road construction. The number of acres of ground disturbance is unknown as the final location and number of wells and/or trench is unknown.

Adaptive mitigation measures, *if needed*, would be maintained indefinitely or until acceptable bedrock groundwater flow conditions are obtained without those measures. This may include maintaining and periodically replacing recharge or extraction wells. The performance of the adaptive mitigation measures would be determined by monitoring the direction of bedrock groundwater flow. If the artificial recharge or pit lake depression option is chosen, a south bedrock flow toward the NorthMet pits would need to be verified. If the groundwater extraction well is chosen, a south flow away from the Northshore pits would need to be verified.

4.0 Technical Summary and Recommendations

The Co-lead Agencies believe that site-specific groundwater monitoring data and the measured lack of surface water effects near the dewatered Northshore pits are consistent with the potential formation of a groundwater mound. This means that downward leakage from surficial deposits into bedrock could create a groundwater mound that would prevent the formation of a northward bedrock flowpath from the proposed NorthMet pits to the Northshore pits.

The Co-lead Agencies have concluded that additional modeling of flowpaths between the proposed NorthMet pits and Northshore pits would not be beneficial. Any additional modeling must reconcile that at present there are insufficient data on which to determine appropriate: 1) vertical hydraulic conductivity for the surficial deposits, especially within the 100 Mile Swamp; 2) horizontal hydraulic conductivities in bedrock (e.g., Virginia Formation; BIF); and 3) homogeneity of hydraulic conductivities within the bedrock units. Each of these is necessary to quantitatively assess the likelihood of a northward bedrock flowpath. Modeling must also reconcile uncertainty regarding the sequence and timing of future Northshore mining operations, including the depth of pit excavations and development of pit lakes relative to NorthMet-related pit conditions in operations and closure. Attempting to incorporate these uncertain parameters into MODFLOW would lead to high uncertainty in model results and is not recommended.

Because the existing data and the NorthMet MODFLOW model do not definitively rule out the theoretical possibility of a northward bedrock flowpath from the proposed NorthMet pits to the Northshore pits, the Co-lead Agencies recommend implementation of a robust monitoring and adaptive management plan to ensure with reasonable certainty that any potential northward bedrock groundwater flowpath from the proposed NorthMet pits to the Northshore pits would be addressed and prevented if necessary. The monitoring program would be situated in bedrock in the area north of the proposed NorthMet pits to measure groundwater levels during and after NorthMet operations. The Co-lead Agencies are confident that monitoring bedrock groundwater levels would detect and provide advance notice that a northward flowpath could occur. If this is the case, then engineered mitigation measures would be implemented to address any northward flowpath toward the Northshore pits.

5.0 References

Barr Engineering (Barr). 2008. Mine Waste Water Management for the PolyMet NorthMet Mine Site, RS22 Technical Detail Report, Appendix B—Groundwater Modeling of the NorthMet Mine Site Version 3.

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